AVEC-Chugach Microturbine Field Tests

December 2003

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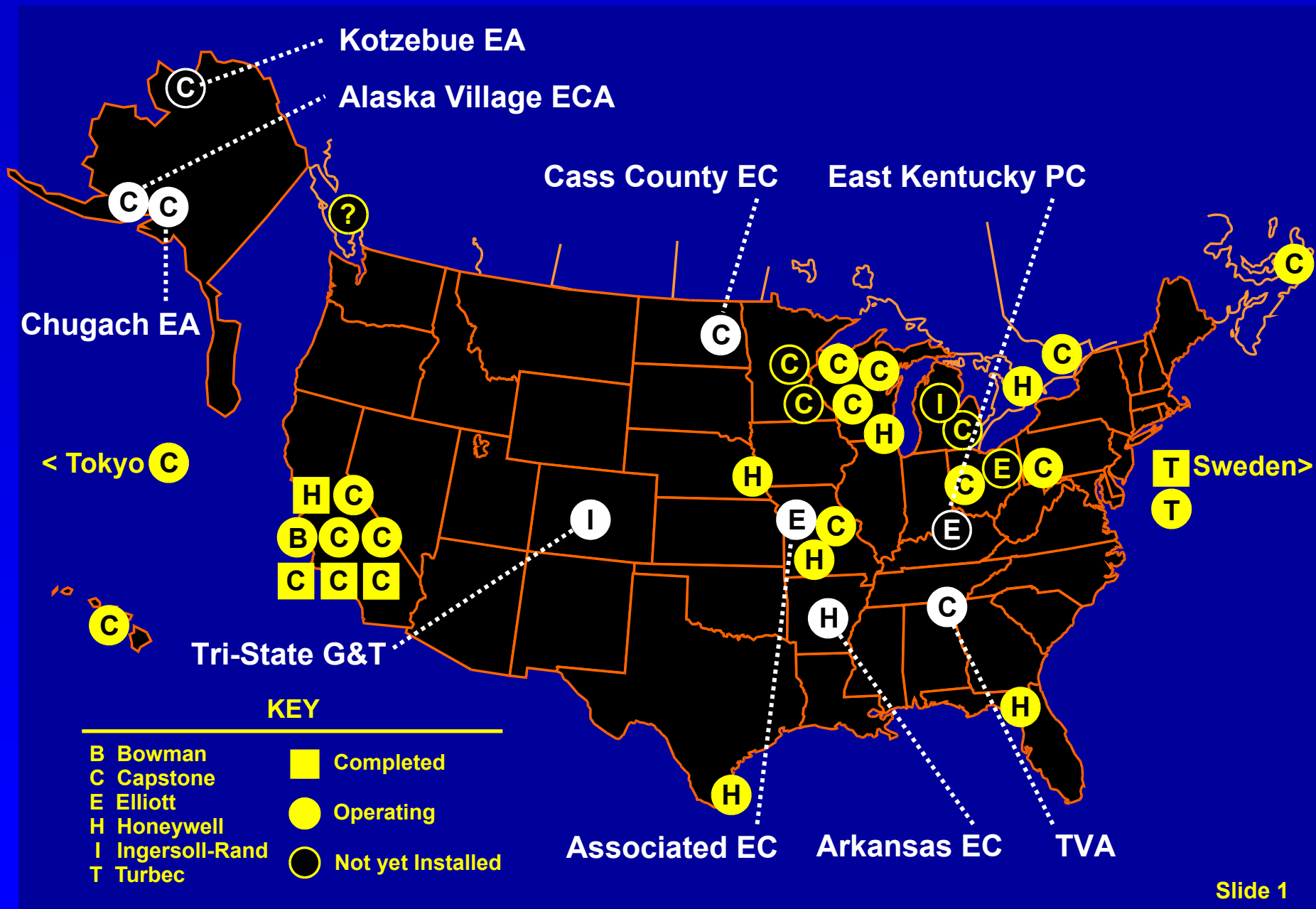
Wide Spectrum and Electric Co-op Role



Capstone

Size: ~ 30 kW and 60 kW
2.3 x 4.4 x 6.3 Feet High
1,100 Pounds

Interconnect: GI, GP, Dual Mode

Experience: 1,900 in field

Fuels: Natural gas, Biogas, Propane. Fuel oil.

Elliott

~ 100 kW

2.7 x 9.2 x 3.9 Feet High

1,900 Pounds

GI, GP

200 in field

Natural gas, Biogas, Propane.

Ingersoll-Rand

~ 70 kW / INDOOR

3.5 x 5.8 x 7.3 Feet High

4,100 Pounds

GI, GP, Dual Mode

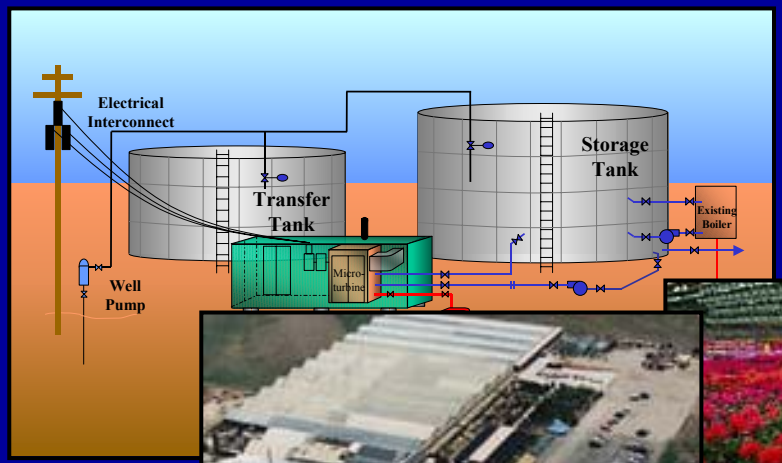
150 in field

Natural gas, Biogas, Propane.

Thermal Recovery Testing

30 kW Capstone

Cass County EC at Holiday Inn Convention Center in Fargo, ND



70 kW Ingersoll-Rand

Tri-State G&T at Tagawa Greenhouse in Brighton, CO

Chugach/AVEC Test Site

Photo courtesy of AVEC/Chugach Field Test
Anchorage, Alaska - March 17, 2002
Record 28.6 inch snowfall, Capstone unit
operated at full output during storm.

Second gas meter / regulator required with separate supply line

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Lockable fused disconnects for access by Chugach crews

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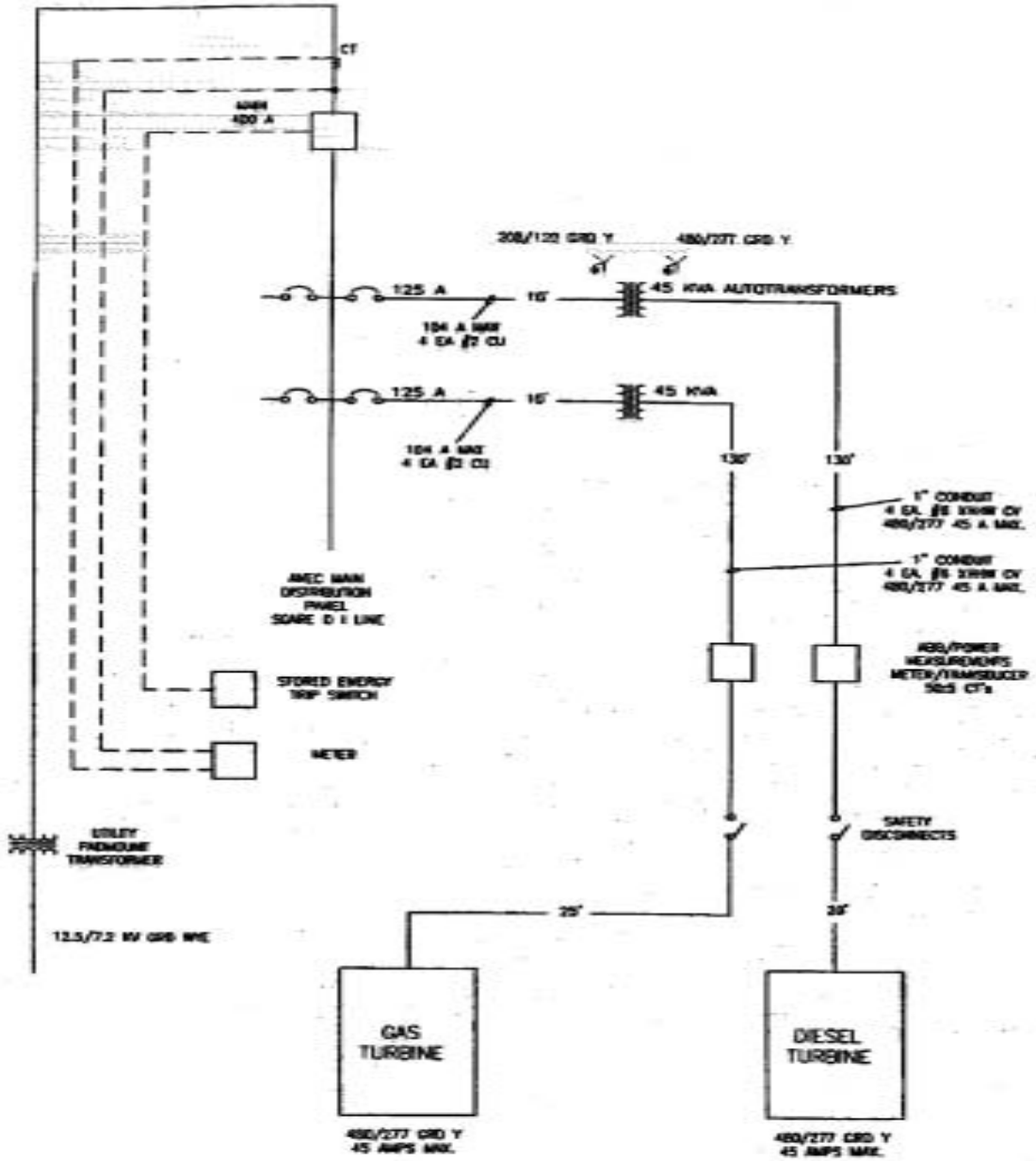

Electrical Interconnection

One Line Diagram of microturbine installation at AVEC

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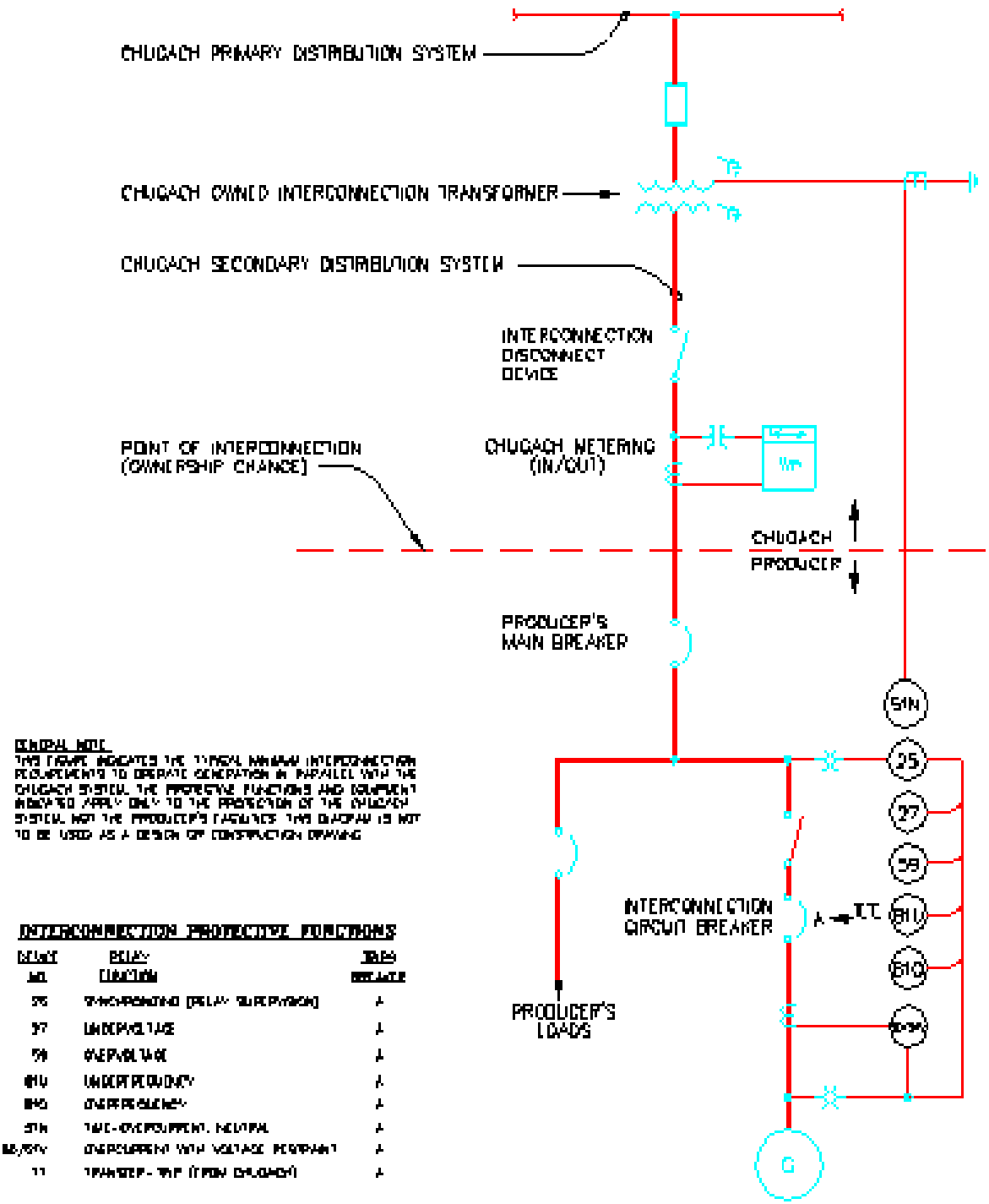
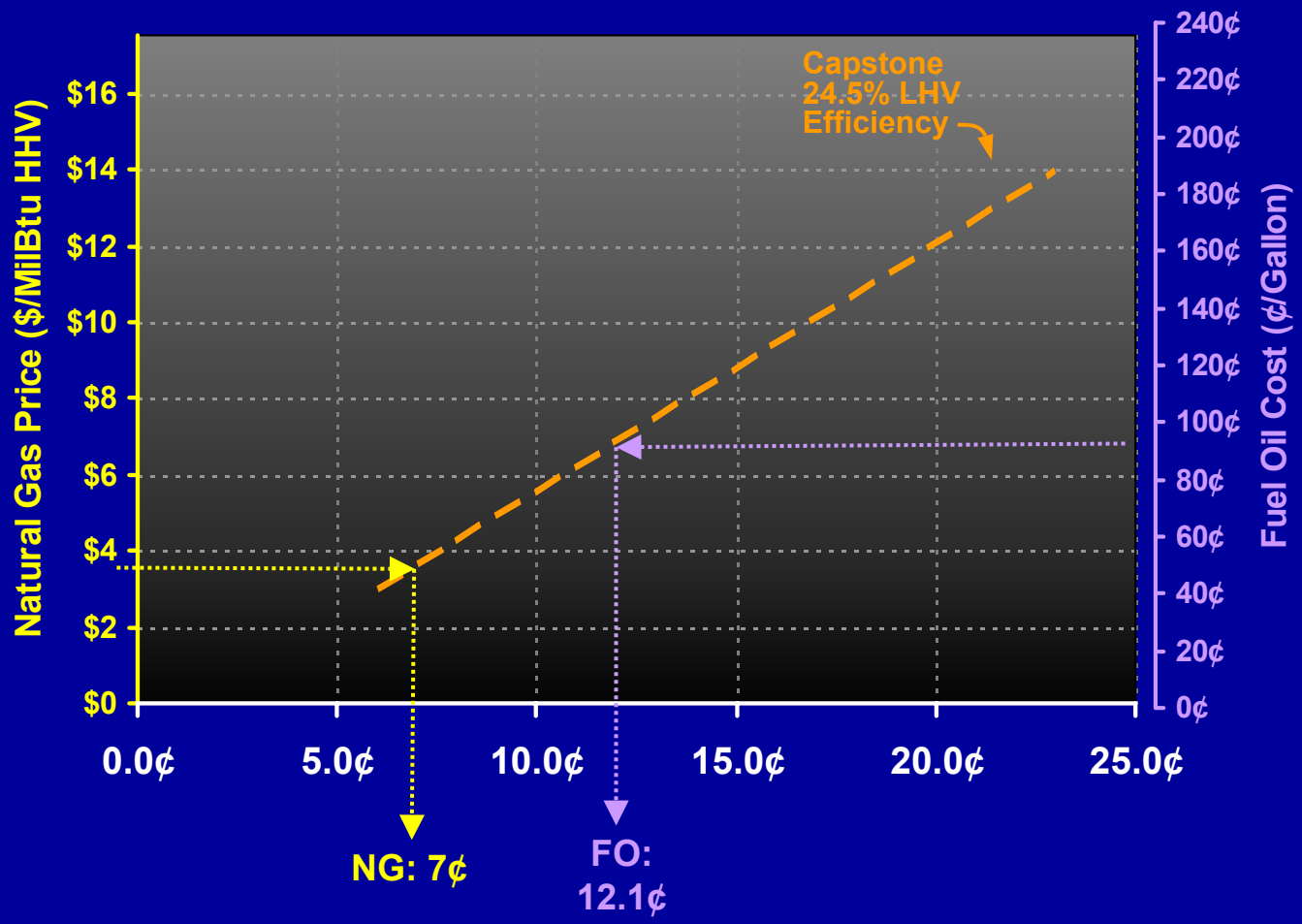


Example from Chugach Interconnect-ion Guidelines 1-5MW

MT Running Cost . . .



Running Cost *(¢/kWh incl 1.1¢/kWh for Maintenance)*

Microturbine Lessons Learned

- Interconnection, electric and gas code issues were early problems
- Noise was an early problem
- We've replaced every major component
- Manufacturer has supported product very well
- Repair is relatively simple

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The Lighter Side

- The building manager hadn't heard the gas fired unit running for 3 months and asked when it would be fixed. – It was running, with the hush kit.

- Warehouse people were feeling ill and blamed the turbine exhaust. – CO monitoring showed the turbine exhaust was cleaner than the warehouse air. The culprit was a faulty propane regulator on a forklift – fixed.

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Conclusions

- **Microturbines with heat recovery may be economic in Anchorage when heat output is matched to thermal loads of the building.**

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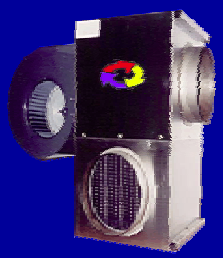
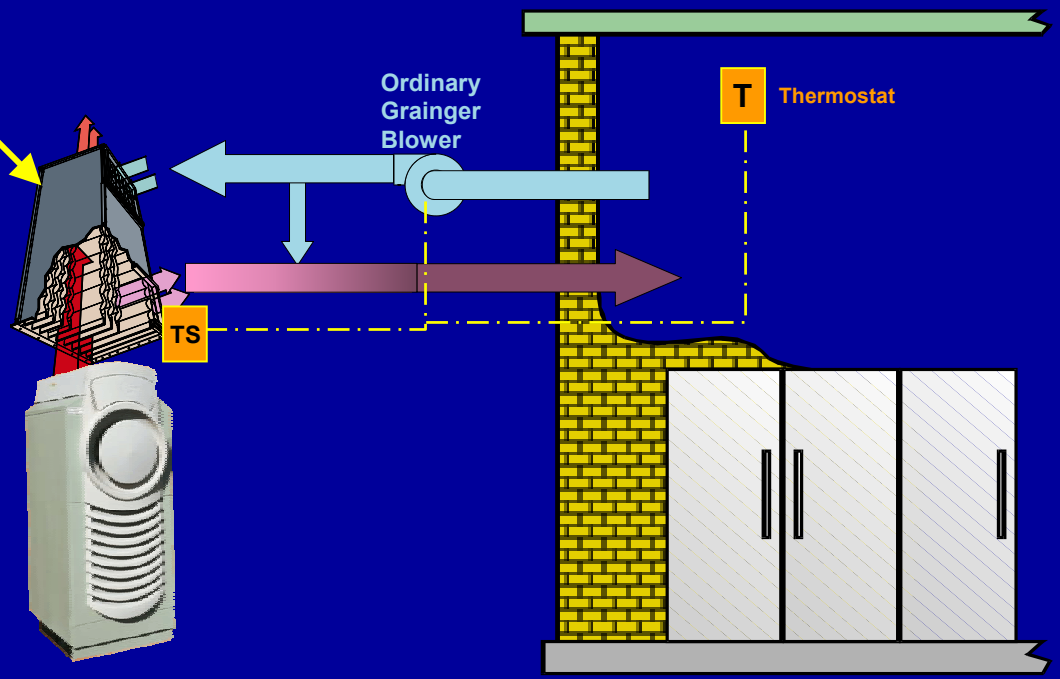
Inexpensive Air-to-Air HEX . . .

$3,600 Exothermics aluminum flat-plate HEX for 30 kW Capstone



Sunwoo Energy, Inc.
$1,500



+ Relatively inexpensive to purchase and install
+ No freeze issues
+ Ordinary HVAC engineer-contractor OK

Why Thermal Recovery Rare . . .

Electric Interconnect:
Value = $45,000 /Year *(70kW @ 8¢)*

- Four 100-amp wires in conduit *~$25 per foot*
- Disconnect and interconnect CB *$1,000*
- Electrical Contractor is likely good enough

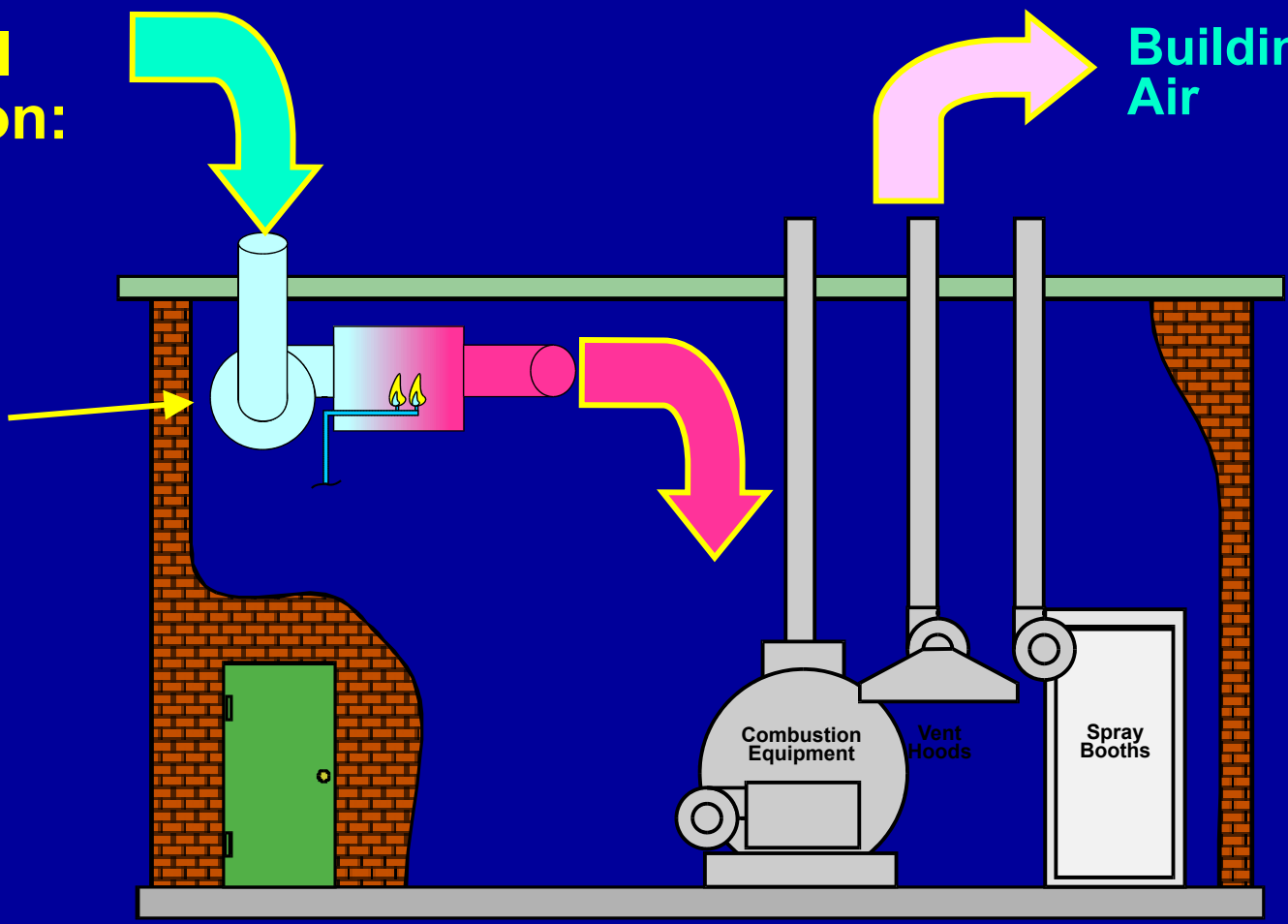
Thermal Recovery:
Value = $15,000 /Year *(0.4 milBtu/hr @ 50% @ $6 / 70%eff)*

- "Good" thermal recovery applications tough to find
- Generally further away than electrical interconnect
- Purchase Thermal Recovery Unit *$6,500*
- Insulated piping pair *~$60 per foot*
- Pumps, valves, controls, etc. *$1,000+*
- Loads - application - interfacing generally not well understood by customer or contractor!
  Consulting Engineer = *$1,000 per day*

What things are not being done …. that might be done …. to make MT thermal recovery more feasible?

Typical Makeup Air Heater . . .

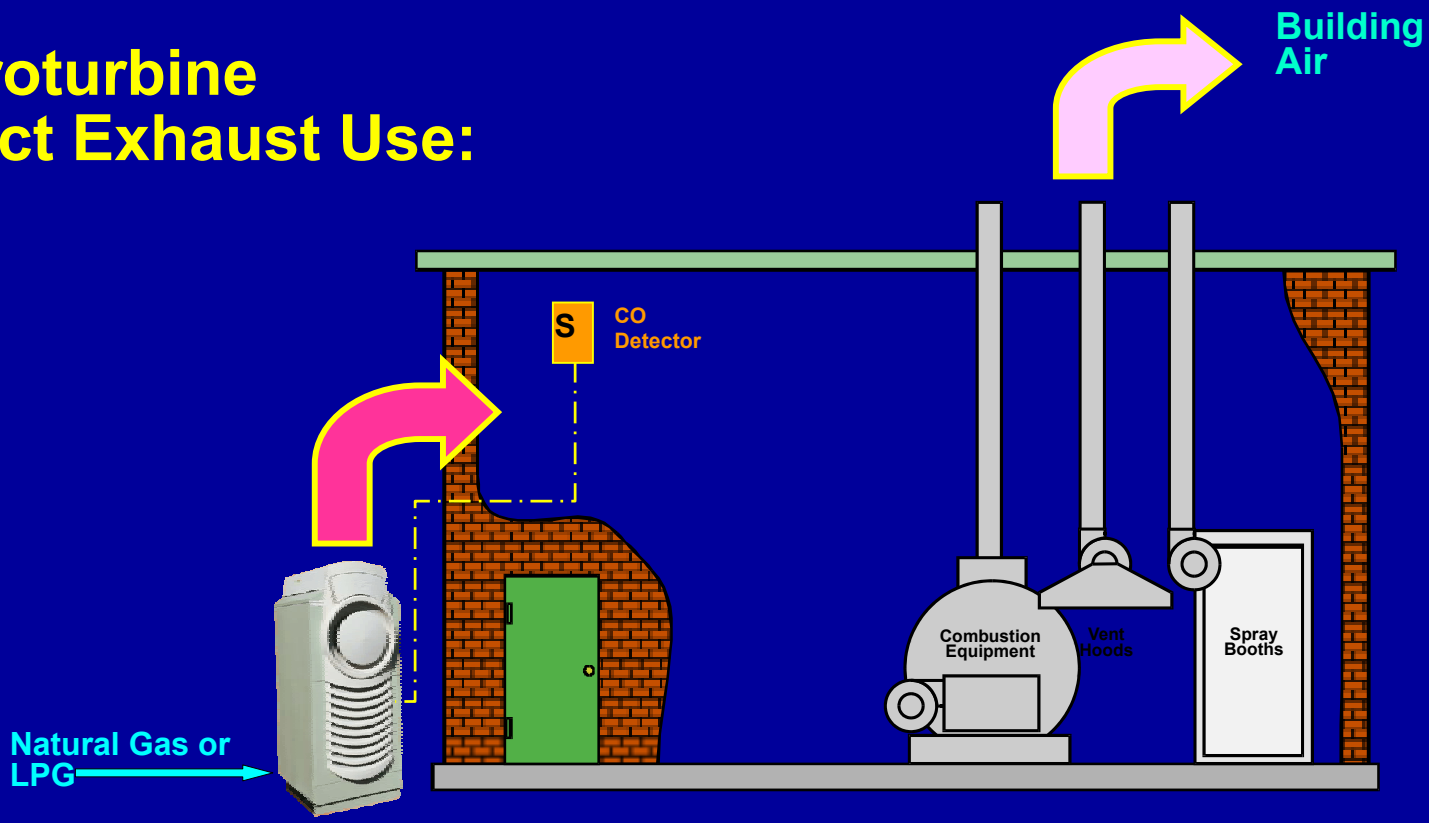
- **Normal Solution:**



Typically used in: warehouses, industrial plants, etc.

Microturbine Direct Makeup Air . . .

- **Microturbine Direct Exhaust Use:**



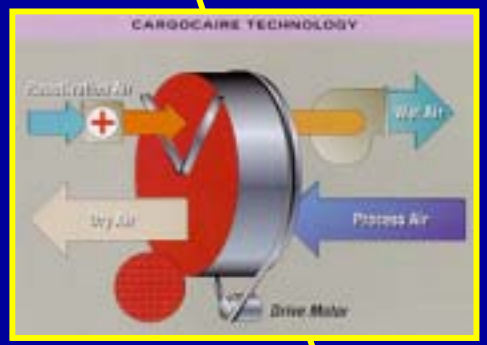
+ Similar to Direct-Fired Makeup Air Heater
+ Inexpensive / 100% Efficient
- Turbine-Exhaust noise? Carbon Monoxide?
- Not Code Approved *(ANSI Z83.18 proxy?)*

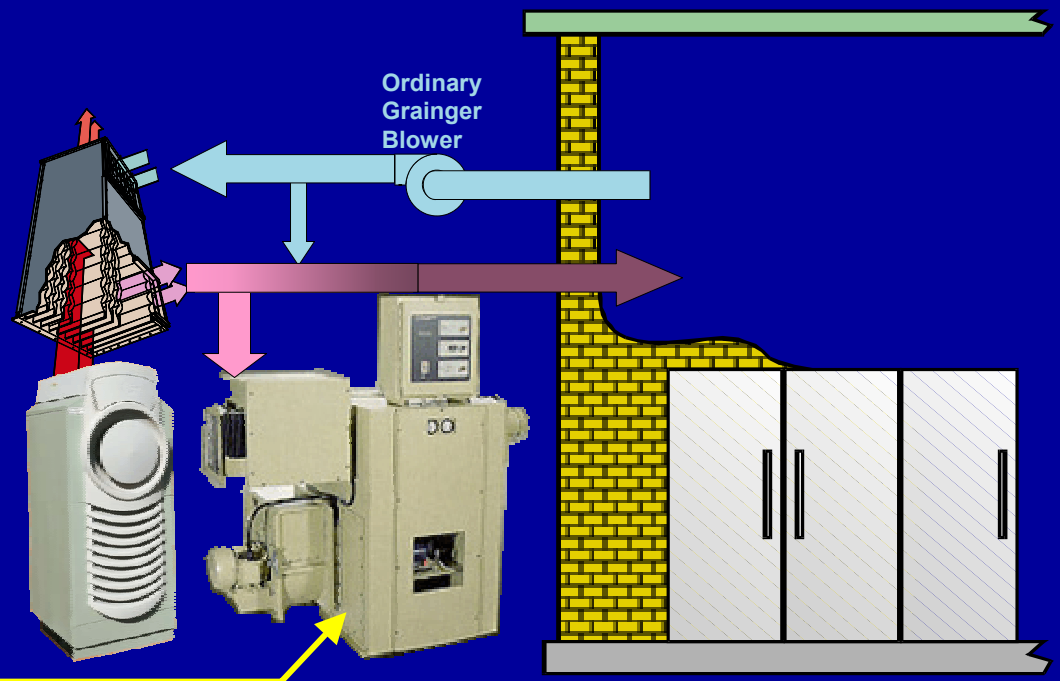
Desiccant Cooling Option . . .

Munters dehumidification unit

$25,000 ex installation*

5 Tons cooling or DEHUMIDIFICATION
(Warehouses, mfg, hotels, retail, etc.)





*A 5-ton rooftop costs about $2,500 to buy and consumes about $1,550 of electricity per 2000-equivalent-full-load-hour-year at 10¢/kWh! However, a desiccant addition may allow the balance of the A/C to save annual operating hours by significantly improving humidity control in the conditioned space.